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Dynamical processes in interstellar molecular ices studied by correlated FEL pulses

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The interaction XUV and VUV radiation with doped molecular ices on grains is important for light-assisted association or dissociation reactions in or on these ices, particularly in accretion disks and the photon dominated regions of interstellar clouds [1]. Important insights into the non-thermal desorption kinetics of CO from pure CO [2] and CO:N2 ice mixtures [3] have been obtained through electronically resonant excitation using quasi-cw synchrotron radiation. For probing the underlying molecular dynamics of bond formation or breaking, as well as the de-sorption process itself, femtosecond duration pulses are required. For studying such processes the VUV/XUV spectral region is of particular importance, because such radiation is abundant in the photon dominated region of interstellar clouds.
Using XUV pulses from the free-electron laser FLASH in Hamburg various molecular ices and ice mixtures were irradiated. Neutral products were state selectively detected by REMPI while ionic desorption products were directly detected by a linear time-of-flight mass spectrometer. Examples to be discussed are the desorption of neutral CO, and the formation of clusters in me-thane/water ice mixtures. Highly nonlinear yields were observed for the latter process which allowed a measurement of the initial dynamics by two-pulse time-correlated desorption. A pre-liminary analysis shows a width of the desorption yield of about 1.5 ps (FWHM), with the peak delayed by less than 500 fs. This points to an electronic process for the primary step, as ex-pected at these photon energies.

[1] K.I. Öberg, Chem. Rev. 116, 9631 (2016)

[2] M. Bertin et al., Phys. Chem. Chem. Phys. 14, 9929 (2012)

[3] M. Bertin et al., Ap. J. 779, 120 (2013)

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